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silt.[5] A foreign resident writing in 1915 took a gloomy view of the city's future because he considered that six storeys was the maximum possible for buildings on this site.[6] These problems have been overcome, at considerable expense, by floating the taller buildings on concrete rafts in order to provide a stable foundation adequate to support structures which would otherwise sink into the alluvium. Until the first experiment with this method in the building of the new Shanghai Club in 1910, large buildings had been set on wooden pilings driven into the silt, and great care was necessary to prevent unequal settling. Shanghai's twenty-storey hotels and public buildings, erected during the 1920's and 1930's, float on their concrete rafts in this jelly-like subsoil, a scant 800 miles from the major earthquake belt running through the Japanese islands, but fortunately in the hundred-year history of the foreign settlements, no serious shocks have occurred.

Surface drainage has also been a constant problem in the development of modern Shanghai. The original site[7] (adjoining the walled Chinese city — map 6) as the British found it in 1842 was a typical agricultural landscape of the Yangtze delta: wet rice paddies and dry cotton fields, crisscrossed by creeks and canals, and with occasional clusters of family villages. This land was subject to frequent floods at high tides by the tidal inflow of water from the Yangtze and the resultant backing up of fresh-water outlets (primarily Soochow Creek and the Whangpoo), and until recently it was still flooded nearly every year in late summer by typhoon winds from the east and accompanying heavy rains. The land within the metropolitan area was gradually raised by filling to permit the building of roads and houses. Filling was easier and cheaper than artificial drainage for all but the swampiest areas and proved adequate for the growth of the city, but it was accomplished only at a considerable expense of money and energy.

The commercial core of the city, concentrated along the Whangpoo frontage, remained regularly subject to flooding. One of the first public works projects to be carried out under the Communist administration (which has attempted to make Shanghai a showplace of efficiency as an advertisement of the virtues of the new regime) was the filling of the lowest places in this downtown area, particu-

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larly its major commercial artery, Nanking Road, which follows fairly closely the course of a small creek culverted early in the period of foreign occupance (map 6). It was thus one of the most frequently flooded areas in the city. Paving along this heavily traveled street through the heart of the hotel and retail district was removed for nearly a mile back from the river, and replaced after the ground level had been raised sufficiently to protect it from all but the worst floods.

The numerous tidal creeks (map 6), characteristic of the lower delta, were useful in the early days of the Settlements as master drains and for demarcating legally and defending militarily Settlement boundaries. They were also used for carrying off sewage, where their tidal ebb was an advantage, and for movement of goods within the city and to and from the hinterland. The so-called Defense Creek at the western limit of the British Settlement of 1848 (map 6) was culverted and covered with a roadway in 1906, a few years after the Settlement had reached its greatest areal extent in 1899, but the Yang Ching Pang, which formed the boundary between the French and International Settlements on the south, remained an open sewer and transport artery until 1915, when as an enclosed culvert it was covered over with a broad boulevard named Avenue Edward VII as a gesture of ideological if not political unity between France and Great Britain. The remaining uncovered creeks are still important transport arteries, and as such key factors in the economic life of the city. While Shanghai has at least to this extent turned its delta site to advantage (and in a largely unique way as we shall see below), the problems which the delta has presented far outweigh its benefits.

The City

The site of the original British Settlement, on the left bank of the Whangpoo at its confluence with Soochow Creek, was determined by the existing walled Chinese city just upstream, whose trade had attracted British interest in a concession there (map 6). Soochow Creek, the original natural and later canalized waterway to the leading delta city of Soochow for which Shanghai served as the port, was the primary factor fixing the Chinese city, and it was

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naturally built on the outside of the bend in the Whangpoo, where tidal scour cut a channel and where it could tap a larger hinterland than on the inside of the bend. It may be assumed that the Chinese city was originally at the junction of Soochow Creek and the Whangpoo, and that since its founding in approximately the fourth century A.D., deposition and alterations in the character of both Creek and River (see the next section of this chapter) have left the city on the Whangpoo about 5000 feet upstream from the Creek's mouth. A considerable area was thus left between the city walls and the mouth of Soochow Creek, and here the British Settlement was established.

Sir Henry Pottinger, head of the British delegation at the Treaty of Nanking, selected the site for the British Settlement at Shanghai on his way back from signing the Treaty, his choice being influenced by strategic considerations.[8] The area he fixed on was the little square bounded on three sides by defensible waterways and on the fourth by the navigable Whangpoo (map 6). The main suburbs of the Chinese city lay between its wall and the Yang Ching Pang, while north of this creek the land-use was agricultural.

The boundaries of the original British leasehold of 1843 and later additions, and of the original French leasehold of 1849, made close use of existing waterways. These were useful not only for demarcation and defense, but also for sewage disposal, drainage, and transport, although not for drinking since they were both brackish and polluted. Roads (including Nanking Road) were built over many of these streams, but they continued to act as sewers. The course of Defense Creek and its junctions suggest that it was canalized for at least part of its length and diverted to supply the moat of the Chinese city, supplementing the water also received from the three other creeks emptying into the moat.

There are no contemporary accounts of natural levees anywhere on this site in 1843, and the possibility of their existence is lessened by the contemporary pattern of streams and canals as it can be reconstructed from period maps and records. Possibly the material which must have been deposited by Soochow Creek and Whangpoo flood waters along their respective banks was continually removed by local farmers in order to spread the alluvium over their fields

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make an overall width more than double the original thirty feet. At the northern end of this embankment, at the mouth of Soochow Creek, the Council made use of some gratuitous real estate, deposited by the Creek around the hulk of a sailing ship wrecked there in 1851, and soon made part of the mainland by continued deposition, for the establishment of a park on the river side of the Bund. A broad boulevard was built from Soochow Creek to the Yang Ching Pang along the new embankment (later extended by the French into their Settlement), and this artificially preserved freeway has been maintained by the modern city as its chief showplace and promenade ground, lined to landward by hotels, banks, trading houses, and public buildings, but on the river side by unsightly floating wharves (necessitated by the annual tidal range of 13.6 feet) and mud flats exposed at low tide.

On this problem also the Communist administration of the city have expressed themselves in another project to dress up China's modern front door to the West. The current project for the Bund (now largely completed) calls for the removal of the railway and street car lines which have run down the middle of the broad embankment, with attendant rickshaw stands and cargo stations, and their replacement by an island to be planted with grass and trees, in a reversion to the original late nineteenth century pattern. Planting is also to be added on the river side of the Bund, to provide some screen in front of the harbor functions which are too important to move, however unsightly.

Water Supply

Water for drinking and for the manifold needs of a large city has been a perennial difficulty, since the brackish Whangpoo is high in carbonates and indifferently potable, while most local wells yield an even less desirable and more limited supply. Only the relatively modest demands of most of the Chinese population and the absence of any large pure-water consuming industries make the water supply adequate for such a large city on this site.

Until 1883 all water used by the foreigners for drinking (aside from that drawn from the few local wells) was dipped from the Whangpoo or Soochow Creek (and by the Chinese from the other

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creeks and canals as well) and settled in earthen jars with the help of alum to precipitate the mud. The water was then boiled and cooled, but this beverage was not held in much favor by the foreign community, and beer, wine and spirits imported from abroad filled most of the needs of at least the male foreign residents, aside from the missionaries. In 1883 a foreign-owned and directed water company under contract to the Shanghai Municipal Council began to supply water to the foreign community in pipes, and this service was gradually extended to Chinese residents of the Settlement after 1884, primarily to help prevent disease, which could so easily spread. This water, pumped from the Whangpoo, was purified by slow sand filters, alum, and chlorine, but it remained unpalatable and was distributed to less than 10,000 users in all until the turn of the century. The intake for this plant has remained on the Whangpoo below the city in south Yangtzepoo.[11]

Location downstream from the city enables the plant to draw on the tidal inflow from the Yangtze, which is less contaminated, fresher, and less muddy near the surface than what the Whangpoo brings down. The widespread use of city refuse of all kinds for fertilizing fields and for filling low-lying land makes a downstream location so near the city less of a danger than it would be in most Western cities. The Whangpoo may originally have been a tidal salt water creek which later benefitted from stream piracy in making connections with a fresh-water stream or streams farther inland as its own headwaters. Such a possibility is suggested by the Whangpoo's short total course compared with the volume of water it carries, by the sharp right-angle bend it makes in flat alluvial country about ten miles above Shanghai (map 5), and by what is known of the hydrographic history of this area, which is discussed in greater detail below.

This private British-owned company, the Shanghai Waterworks Ltd., continued to provide about half of the piped water supply of the entire city until 1936, by which time it distributed a daily average of about 54 million gallons. It was supplemented in 1903 by a company owned by the government of the French Settlement with an intake above the city on the Whangpoo, and also using sand filters, alum, and chlorine to supply a daily average of about 32 million

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gallons by 1936. Two Chinese-owned waterworks were also in operation, one in Chapei (part of the Chinese municipality — map 3) established in 1921 and drawing water from an intake on the Whangpoo just above Woosung. This was the largest Chinese-owned waterworks in China, and supplied an average of about ten million gallons daily. The other Chinese waterworks was built in 1906 in Nantao, with an intake just upstream from that of the French company, but it operated intermittently until 1930, and by 1936 supplied only about three million gallons daily. These two Chinese waterworks served a tiny fraction of the Chinese population outside the foreign settlements, primarily in the areas immediately adjoining the Settlements on the northwest and south. Both plants used sand filters and chlorine to purify their water, but in 1926 the supply of the Chapei company was found to be grossly polluted and probably responsible for a cholera epidemic in that year in which several foreign as well as several hundred Chinese cases were reported.[12]

Aquiferous sand strata with water pockets of some size underlie parts of the city's site at depths of 100 feet or more, and most of the textile and paper factories have tapped this relatively pure and soft water by wells deeper than those dug during the early days of the Settlement. Drilling in the alluvium is cheap, but while water thus obtained appears to be satisfactory for soft-water using industries, it is questionable whether it is renewable and will not soon be exhausted, and certainly whether it is adequate to supply even a small part of the city's needs.

Despite the chemical purity of the water supplied by at least the two foreign companies, most foreign residents continued into the 1930's to boil and filter it before using it for drinking, an old habit which died hard and which was doubtless prolonged by the unpleasant taste of the heavily treated water. The total piped and treated water consumption of the entire city in 1936, approximately 100 million gallons a day exclusive of private wells, would not have supplied New York in the same year (with a population a little less than twice that of Shanghai) for more than two and a half hours.*

* New York used approximately one billion gallons a day in 1936, according to the 1936 edition of the New York *World Almanac*.

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505 drawing fifteen feet and for the same distance at low water for vessels drawing six feet. Smaller steam launches use the river for about 700 miles at all seasons. The Hsi system, however, drains only about 210,000 square miles, and contains no such extensive lowland as the Yangtze basin (map 2).

On the Yangtze there is an all-year ship channel for 5,000-ton ships as far as Hankow, 600 miles from the river's mouth, and a summer (high-water period) channel to Hankow for 10,000-ton ships. Above Hankow, permanent steamship service is maintained as far as Chungking, 1400 miles from the sea, by vessels up to 2,000-tons, and river steamers also operate to Suifu (Ipin, Süchow), 150 miles farther upstream where the Yangtze leaves the mountain mass of central Asia and is joined by its navigable tributary, the Min, from the western part of the Red Basin of Szechuan. Map 4 shows the extent to which the river's tributaries are navigable by different sized ships (Suifu on this map is referred to as Süchow). The total of inland waterways navigable from Shanghai by junks at all seasons (excluding the canals of the delta) is nearly 30,000 miles, reaching approxi-
434 mately 200,000,000 people. This transport network is reflected in the fact that Shanghai between 1865 and 1936 handled between 45 and 65 per cent of the total foreign trade of China by value.

503 The Yangtze system feeding Shanghai is reproduced in miniature
505 within the delta itself (map 5). A maze of canals dissects the fertile triangle, connecting with natural waterways to form through water links between every village and town in this area and from
312 all of them to Shanghai. The canals are used primarily for transport, but they also serve as sources of irrigation water for wet paddies and as community water supplies, in addition to providing drainage, which may have been their original purpose.[2] The alteration of the natural environment which the canals represent has been in progress for at least the last 2,000 years, and now constitutes probably the largest concentration of artificial waterways anywhere in the world.

When the canals are added to Tai Lake and the chain of smaller lakes to its east, the Yangtze, the Whangpoo, Soochow Creek, and many smaller rivers in this area, the landscape becomes an enormously magnified Venice. Within a radius of at least 100 miles from Shanghai it is possible to go from any village or town to any other